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(54) Method and apparatus for giving vibration to molten metal in twin roll continuous casting machine

Verfahren und Vorrichtung zum Erzeugen von Schwingungen in einer Metallschmelze beim Stranggiessen mittels Doppelwalzen

Procédé et dispositif de mise en vibration d'un métal en fusion pendant la coulée continue entre deux cylindres

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Description

[0001] The present invention relates to a method and apparatus for giving vibration to molten metal in twin roll continuous casting machine.

[0002] In a twin roll continuous casting machine, between upper surfaces of opposite ends of a pair of rolls arranged horizontally and in parallel with each other, seal plates called side dams are abutted to confine a melt pool above a nip between the rolls. Molten metal is supplied to the pool and is solidified on the roll surfaces. The rolls are rotated under this condition so that solidified shells formed on the roll surfaces are pulled down together to directly cast a strip.

[0003] Fig. 7 represents a conventional twin roll continuous casting machine. As shown in the figure, a pair of rolls 1 and 2, which are internally coolable, are arranged horizontally and in parallel with each other with a predetermined nip. Between upper surfaces of opposite ends of the rolls 1 and 2, seal plates called side dams 3 are abutted to confine a melt pool 4 above the nip between the rolls 1 and 2.

[0004] In order to supply the molten metal 5 to the pool 4, a tundish 6 is arranged above the pool 4 and has a pouring nozzle 7 protruded from the tundish 6 to the pool 4.

[0005] Further, an inert gas chamber 8 is provided under the tundish 6 to surround the pool 4. The chamber 8 is partitioned into upper and lower portions by a straightening plate 9 such as punched plate and has inert gas inlets 11 arranged in the chamber 8 at positions above the plate 9 so as to supply inert gas 10 such as nitrogen or argon gas to the chamber for prevention of the molten metal 5 in the pool 4 from being oxidised.

[0006] Reference numeral 12 denotes solidified shells on the surfaces of rolls 1 and 2; and 13, a produced strip.

[0007] Thus, the molten metal 5 in the tundish 6 is supplied to the melt pool 4 via the nozzle 7 and is solidified on the surfaces of the rolls 1 and 2. Under this condition, the rolls 1 and 2 are rotated in the direction of the arrows shown in the figure so that the solidified shells 12 formed on the surfaces of the rolls 1 and 2 are pulled down together to continuously cast the strip 13.

[0008] Disadvantageously in the conventional twin roll continuous casting machine as described above, the produced strip 13 is so thin in thickness that its production yield per machine is lower than that of an ordinary slab continuous casting machine. For the purpose of increasing the production yield, measures are being taken into consideration such as designing a twin roll continuous casting machine itself in larger size or enhancing the productivity through drastic enhancement of the solidification efficiency and increase of rotating velocity of rolls. There is, however, limitation in terms of facilities and equipment to make a large-sized twin roll continuous casting machine and therefore there are strong demands on technical development of enhancing the solidification efficiency for enhanced productivity.

[0009] As means or measure for enhancing the solidification efficiency of molten metal, it has been reported in recent years that high frequency vibration of about 5 to 10 kHz applied to molten metal remarkably enhances the solidification efficiency of the molten metal. The inventors have studied application of such solidification behaviour of molten metal to a twin roll continuous casting machine.

[0010] In attempt of mechanically vibrating the rolls 1 and 2 with respect to the molten metal 5 in the melt pool 4, mechanically vibrating the rotating rolls 1 and 2 has been proposed according to WO 94/12300 but is difficult to carry out. It is, therefore, practically impossible to mechanically vibrate with very small amplitude in the order of microns to produce high frequency vibration of about 5 to 10 kHz.

[0011] US-A-4523628 described radially vibrating molten metal in a casting mould by simultaneously applying a stationary magnetic field by a DC coil provided at the top of the mould, and a variable magnetic field by an annular AC coil surrounding the mould, thereby to vibrate the entire mass of metal. For a continuous caster the use of several DC and AC coils arranged alternately along the path of the solidifying metal is proposed.

[0012] The present invention was made in view of the above and has its object to provide a method and an apparatus for giving vibration to molten metal in a twin roll continuous casting machine in which high frequency vibration can be applied efficiently and effectively to molten metal in a melt pool to enhance solidification efficiency of the molten metal.

SUMMARY OF THE INVENTION

[0013] Accordingly, the present invention provides a method for giving vibration to molten metal in a twin roll continuous casting machine, characterised in that, vibration is imparted to an edge margin of molten metal along a meniscus defined by the molten metal of the casting pool by applying simultaneously a DC magnetic field and an AC magnetic field at and along the meniscus thereby generating induction current in the molten metal, and giving high frequency vibration to said molten metal edge margin by Lorentz's force due to interaction of said induction current with said DC magnetic field.

[0014] The present invention also provides apparatus for giving vibration to molten metal in a casting pool of a continuous casting machine having at least one roll characterised in that an AC electromagnet is arranged substantially directly above a meniscus defined by the molten metal in a casting pool and a casting surface of said at least one roll over the length of the meniscus such that magnetic fluxes run substantially perpendicular to a surface of said molten metal and a DC electro-

magnet is arranged over the length of said AC electromagnet such that magnetic fluxes run substantially perpendicular to the surface of the molten metal thereby to induce high frequency relative vibratory movement between the molten metal of the casting pool and the casting surface of said at least one roll along the meniscus.

[0015] Preferably, the AC and DC electromagnets are held by water-cooled jackets, respectively.

[0016] Therefore, in the method for giving vibration to molten metal in a twin roll continuous casting machine according to the present invention, electromagnetic forces can be utilised to apply high frequency vibrations on non-contact basis to the molten metal in a melt pool. As a result, remarkably improved is solidification efficiency of the molten metal, in particular, initial solidification efficiency near the meniscus.

[0017] In the apparatus for giving vibration to molten metal in a continuous casting machine according to the present invention, the DC electromagnet is energised to apply the DC magnetic field to the molten metal in the molten metal pool and the AC electromagnet is energised to apply the AC magnetic field near the meniscus of said molten metal and the casting surface or surfaces. As a result, induction current (eddy current) running axially of the rolls, which is generated in the molten metal by said AC magnetic field, interacts with said DC magnetic field to generate Lorentz's force in horizontal direction perpendicular to the direction of magnetic fluxes of the DC magnetic field and perpendicular to the flowing direction of the induction current according to Fleming's rule, and the molten metal is vibrated with high frequency in accordance with AC frequency by Lorentz's force.

[0018] Further, when the AC and DC electromagnets are held by water cooled jackets, respectively, the AC and DC electromagnets can be protected from heat of the molten metal.

[0019] The AC electromagnet may comprise an elongated comblike core having an elongated plate-like body and a plurality of equispaced projections extending from a longitudinal edge thereof and an AC coil wound around the outer periphery of the core.

[0020] In an alternative embodiment, the AC electromagnet may comprise a plurality of rod-like cores, each core having an AC coil wound cylindrically there around.

[0021] The present invention further provides a method of continuously casting metal strip comprising:

introducing molten metal into a nip between a pair of parallel casting rolls via metal delivery means disposed above the hip to create a casting pool of molten metal supported on casting surfaces of the rolls immediately above the nip;
counter-rotating the casting rolls to deliver a solidified metal strip downwardly from the nip; and
applying high frequency vibratory movement to the molten metal of the casting pool, characterised by applying simultaneously a DC magnetic field and an AC magnetic field to edge margins of the molten metal of the casting pool extending along a meniscus defined by the molten metal of the pool and the casting surfaces of the rolls to induce high frequency relative vibratory movement between the molten metal of the casting pool and the casting surfaces of the rolls along the meniscus.

[0022] Preferably the AC magnetic field is applied near the meniscus defined by the molten metal of the casting pool and the casting surface of the rolls by means of a pair of AC electromagnets, each AC electromagnet being disposed above the meniscus of each respective roll and extending substantially parallel thereto, the DC magnetic field being applied by DC electromagnet elements arranged above the AC electromagnets.

[0023] The present invention further provides apparatus for continuously casting metal strip comprising a pair of parallel casting rolls forming a nip between them, metal delivery means for delivery of molten metal into the nip between the casting rolls to form a casting pool of molten metal supported on casing roll surfaces immediately above the nip, roll drive to drive he casting rolls in counter-rotational direction to produce a solidified strip of metal delivered downwardly from the nip, and vibration means operable to induce high frequency relative vibratory movement between the molten metal of the casting pool and the casting surfaces of the rolls, characterised in that the vibration means comprises means to provide an AC electromagnet field and means to provide a DC electromagnet field, said AC electromagnet means being arranged substantially directly above an edge margin of the molten metal of the casting pool and extending along the length of a meniscus defined by the molten metal of the casting pool and the casting surfaces of the rolls such that magnetic fluxes run substantially perpendicular to the surface of the molten metal, and said DC electromagnetic means is arranged over the length of said AC electromagnetic means such that magnetic fluxes run substantially perpendicular to the surface of the molten metal.

[0024] Preferably the AC electromagnet means comprises a pair of substantially parallel spaced apart AC electromagnets with each AC electromagnet being arranged substantially above the respective meniscus defined by the molten metal of the casting pool and the casting surfaces of each roll over the length of the meniscus.

[0025] Each AC electromagnet may comprise an elongated comb-like core having an elongated plate-like body and a plurality of equispaced projections extending from a longitudinal edge thereof, and an AC coil wound around the outer periphery of the core.

[0026] In an alternative embodiment, each AC electromagnet may comprise a plurality of rod-like cores, each core having an AC coil wound cylindrically there around.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] Embodiments of the present invention will now be described in conjunction with the drawings.

- Fig. 1 A front view in section of an embodiment of the present invention.
- Fig. 2 A perspective view of the AC electromagnet shown in Fig. 1.
- Fig. 3 A enlarged front view for explaining applied direction of Lorentz's force to the molten metal.
- Fig. 4 A view for explaining adjustment of flux distribution in an AC magnetic field by use of a non-magnetic screen.
- Fig. 5 An enlarged cross-sectional view of another embodiment of the AC electromagnet illustrated in Fig. 2.
- Fig. 6 A perspective view of another embodiment of the present invention.
- Fig. 7 A front view in section of a conventional apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0028] Figs. 1 to 4 represent an embodiment of the present invention.

[0029] The same components as those shown in Fig. 7 are referred to by the same reference numerals.

[0030] Substantially directly above meniscus 14 (where surface of a molten metal 5 contacts the surface of each of rolls 1 and 2) defined by the molten metal 5 in a melt pool 4 above the nip between the rolls 1 and 2 and by each of the rolls 1 and 2, an AC electromagnet 15 is arranged over the entire length of the meniscus 14 so that magnetic fluxes run substantially perpendicular to the surface of the molten metal 5. Above the AC electromagnet 15, a DC electromagnet 16 is arranged over the entire length of the AC electromagnet 15 such that magnetic fluxes run substantially perpendicular to the surface of the molten metal 5.

[0031] Each AC electromagnet 15 comprises, as shown in Fig. 2, an AC coil which is wound substantially horizontally around an outer periphery of an elongated plate-like core 26. The core 26 extends axially of the roll 1 and 2 (only the roll 2 is shown in Fig. 2) and the AC coil 17 is connected to an AC power source (not shown) outside of an inert gas chamber 18 which surrounds the coil 17.

[0032] The DC electromagnet 16 comprises a DC coil 20 which is wound substantially horizontally around upper and outer periphery of a pouring nozzle 19 extending axially of the rolls 1 and 2 and which is connected to a DC power source (not shown) outside the chamber 18.

[0033] Further, in this embodiment, the electromagnets 15 and 16 are held by water-cooled jackets 21 and 22, respectively, and are cooled by coolant water supplied to and discharged from each of the jackets 21 and 22 from and to the outside of the chamber 18. The jacket 21 for the AC electromagnet 15 is supported by a support 23 which extends axially of the rolls 1 and 2 and which is fixed at its opposite ends to front and rear walls of the inert gas chamber 18. The jacket 22 for the DC electromagnet 16 is supported by the nozzle 19 and by the bottom of the tundish 6.

[0034] In Fig. 1, reference numeral 24 represents heat insulating material which is used for thermal insulation between the nozzle 19 and bottom of the tundish 6 and the water-cooled jackets 21 and 22.

[0035] Thus, the DC electromagnet 16 is energised to apply DC magnetic field on the molten metal 5 in the melt pool 4 and the AC electromagnet 15 is energised to apply AC magnetic field near the meniscus 14 defined by the molten metal 5 and each of the rolls 1 and 2. Then, induction current (eddy current) flowing axially of the rolls 1 and 2, which is generated in the molten metal 5 by said AC magnetic field, interacts with the DC magnetic field to generate Lorentz's force in horizontal direction (shown by the arrow B in Fig. 3) perpendicular to the direction of magnetic fluxes of the DC magnetic field (shown by the arrow A in Fig. 3) and perpendicular to the flowing direction of the induction current (perpendicular to the paper plane of Fig. 3) according to Fleming's rule. Said Lorentz's force gives vibration to the molten metal 5 with high frequency of about 5 to 10 kHz in accordance with AC frequency.

[0036] In this case, a non-magnetic screen 25 may be inserted as shown in Fig. 4 to adjust magnetic flux distribution in the AC magnetic field so as to ensure better applied position and intensity of the Lorentz's force.

[0037] Therefore, according to the above embodiment, electromagnetic forces are utilised to give high frequency vibration on non-contact basis to the molten metal 5 in the melt pool 4 to thereby remarkably enhance the solidification efficiency of the molten metal 5, in particular, initial solidification efficiency near the meniscus 14. This enables increase of rotating velocity of the rolls, thereby drastically enhancing the productivity.

[0038] Additionally, enhancement of the solidification efficiency of the molten metal 5 can enhance separability of the solidified shells 12 from the surface of the rolls, which contributes to improved surface property of the strip 13.

[0039] Further, when the AC and DC electromagnets 15 and 16 are held by the water-cooled jackets 21 and 22 as shown in the present embodiment the electromagnets 15 and 16 can be protected from heat of the molten metal 5, which contributes to drastic enhancement of durability of the electromagnets 15 and 16.

[0040] Fig. 5 represents another embodiment of the AC electromagnet illustrated in Fig. 2. The AC electromagnet as illustrated in Fig. 5 comprises an elongated comb-like core 36 having an elongated plate-like body

and a plurality of equi-spaced projections extending from one longitudinal edge thereof, and an AC coil 27 which is wound substantially horizontally around an outer periphery of the plate-like body of the core 36.

[0041] In relation to the amplitude of vibration of the molten metal, it has been found that the smaller the pitch (p) of the AC magnetic field, the greater the amplitude becomes. Thus the smaller the pitch between adjacent projections, the more effective the core becomes in providing greater amplitude. However too small a pitch between projections would lead to a uniform magnetic field. It has been found that a projection pitch of 5 mm produces an effective vibration of the molten metal of the pool.

[0042] Fig. 6 represents another embodiment of the present invention in which the AC electromagnet 15, which is arranged substantially directly above the meniscus 14 so that magnetic fluxes run substantially perpendicular to the surface of the molten metal 5, comprises a plurality of AC coils 37 each of which is wound cylindrically around a rod-like core 46. Also in this case, an AC magnetic field similar to that in the above embodiment can be formed so that induction current (eddy current) running axially of the rolls 1 and 2 can be generated to give high frequency vibration to the molten metal 5 in the melt pool 4.

[0043] It is needless to say that the method and the apparatus for giving vibration to molten metal in a twin roll continuous casting machine according to the present invention are not limited to the above embodiments and that various changes and modifications may be made without departing from the scope of the claims. For example, the means to provide the AC electromagnetic field may be in the form of one AC electromagnet extending the length of the casting pool.

[0044] According to the method and the apparatus for giving vibration to molten metal in a twin roll continuous casting machine of the present invention, various superb effects as given below can be attained.

(I) Since electromagnetic forces are utilised to give high frequency vibration on non-contact basis to the molten metal in the melt pool, solidification efficiency of the molten metal, in particular, initial solidification efficiency near the meniscus can be remarkably enhanced, which enables increase of rotating velocity of the rolls to drastically improve productivity.

(II) Enhancement of solidification efficiency of the molten metal enhances separability of the solidified shell from the roll surfaces, which contributes to improved surface property of the produced strip.

(III) In the apparatus for giving vibration to molten metal in a twin roll continuous casting machine of the present invention, when the AC and DC electromagnets are held by the water-cooled jackets, the electromagnets can be protected from heat of the molten metal, which contributes to drastic enhancement of durability of the electromagnets.

Claims

1. A method of continuously casting metal strip comprising:

    introducing molten metal (5) into a nip between a pair of parallel casting rolls (1,2) via metal delivery means (19) disposed above the nip to create a casting pool (4) of molten metal (5) supported on casting surfaces of the rolls (1,2) immediately above the nip;
    counter-rotating the casting rolls (1,2) to deliver a solidified metal strip (13) downwardly from the nip; and
    applying high frequency vibratory movement to the molten metal (5) of the casting pool, characterised by applying simultaneously a DC magnetic field and an AC magnetic field to edge margins of the molten metal (5) of the casting pool (4) extending along a meniscus (14) defined by the molten metal of the pool and the casting surfaces of the rolls (1,2) to induce high frequency relative vibratory movement between the molten metal (5) of the casting pool (4) and the casting surfaces of the rolls (1,2) along the meniscus (14).

2. A method as claimed in claim 1 wherein the AC magnetic field is applied along an edge margin of the pool extending along a meniscus (14) defined by the molten metal (5) of the casting pool (4) and the casting surface of the rolls (1,2) by means of a pair of AC electromagnets (15), each AC electromagnet (15) being disposed above the meniscus of each respective roll (1,2) and extending substantially parallel thereto and wherein the DC magnetic field is applied by means of DC electromagnet elements arranged above the AC electromagnets (15).

3. Apparatus for continuously casting metal strip comprising a pair of parallel casting rolls (1,2) forming a nip between them, metal delivery means (19) for delivery of molten metal (5) into the nip between the casting rolls (1,2) to form a casting pool (4) of molten metal (5) supported on casing roll surfaces immediately above the nip, roll drive to drive the casting rolls in counter-rotational direction to produce a solidified strip (13) of metal delivered downwardly from the nip, and vibration means operable to induce high frequency relative vibratory movement between the molten metal (5) of the casting pool (4) and the casting surfaces of the rolls, characterised in that the vibration means comprises means (15) to provide an AC electromagnet field and means (16) to provide a DC electromagnet field, said AC electromagnet means (15) being

arranged substantially directly above an edge margin of the molten metal (5) of the casting pool (4) and extending along the length of a meniscus (14) defined by the molten metal of the casting pool (4) and the casting surfaces of the rolls such that magnetic fluxes run substantially perpendicular to the surface of the molten metal, and said DC electromagnetic means (16) is arranged over the length of said AC electromagnetic means (15) such that magnetic fluxes run substantially perpendicular to the surface of the molten metal.

4. Apparatus as claimed in claim 3 wherein the AC electromagnet means comprises a pair of substantially parallel spaced apart AC electromagnets (15) with each AC electromagnet being substantially above the respective meniscus (14) defined by the molten metal (5) of the casting pool (4) and the casting surface of each roll (1,2) over the length of each meniscus (14).

5. Apparatus as claimed in claim 4, wherein the DC electromagnet means (16) comprises substantially parallel DC electromagnet elements arranged substantially above and extending the length of the respective AC electromagnets (15).

6. Apparatus as claimed in claim 4 or 5 wherein the AC and DC electromagnets (15,16) are held by water cooled jackets (21,22), respectively.

7. Apparatus as claimed in any one of claims 4 to 6 wherein each AC electromagnet (15) comprises an elongated comb-like core (36) having an elongated plate-like body and a plurality of equispaced projections extending from a longitudinal edge thereof, and an AC coil (27) wound around the outer periphery of the core (36).

8. Apparatus as claimed in any one of claims 4 to 6 wherein each AC electromagnet (15) comprises a plurality of rod-like cores (46), each core (46) having an AC coil (37) wound cylindrically there around.

9. A method for giving vibration to molten metal in a twin roll continuous casting machine, characterised in that, vibration is imparted to an edge margin of molten metal along a meniscus (14) defined by the molten metal of the casting pool by applying simultaneously a DC magnetic field and an AC magnetic field at and along the meniscus (14) thereby generating induction current in the molten metal (5), and giving high frequency vibration to said molten metal edge margin by Lorentz's force due to interaction of said induction current with said DC magnetic field.

10. Apparatus for giving vibration to molten metal in a casting pool of a continuous casting machine having at least one roll (1,2) characterised in that an AC electromagnet (15) is arranged substantially directly above a meniscus (14) defined by the molten metal (5) in a casting pool (4) and a casting surface of said at least one roll (1,2) over the length of the meniscus (14) such that magnetic fluxes run substantially perpendicular to a surface of said molten metal (5) and a DC electromagnet (16) is arranged over the length of said AC electromagnet (15) such that magnetic fluxes run substantially perpendicular to the surface of the molten metal thereby to induce high frequency relative vibratory movement between the molten metal of the casting pool and the casting surface of said at least one roll along the meniscus.

11. Apparatus as claimed in claim 10, wherein the AC and DC electromagnets (15,16) are held by water-cooled jackets (21,22), respectively.

12. Apparatus as claimed in claim 14 or claim 15 wherein the AC electromagnet (15) comprises an elongated comb-like core (36) having an elongated plate-like body and a plurality of equispaced projections extending from longitudinal edge thereof, and an AC coil (27) wound around the outer periphery of the core (36).

13. Apparatus as claimed in claim 10 or 11 wherein the AC electromagnet (15) comprises a plurality of rod-like cores (46), each core (46) having an AC coil (37) wound cylindrically there around.

Patentansprüche

1. Verfahren zum Stranggießen von Metallband, mit den folgenden Schritten:

   Einbringen von schmelzflüssigem Metall (5) in einen Spalt zwischen einem Paar paralleler Gießwalzen (1,2) über eine Metallabgabeeinrichtung (19), die oberhalb des Spalts angeordnet ist, um einen Gießvorrat (4) aus schmelzflüssigem Metall (5) zu erzeugen, der auf den Gießflächen der Walzen (1,2) unmittelbar oberhalb des Spalts gehalten wird;
   gegenläufige Drehung der Gießwalzen (1,2), um ein erstarrtes Metallband (13) aus dem Spalt nach unten auszutragen; und
   Anlegen einer hochfrequenten Schwingungsbewegung an das schmelzflüssige Metall des Gießvorrats, gekennzeichnet durch gleichzeitiges Anlegen eines Gleichstrommagnetfeldes und eines Wechselstrommagnetfeldes an Randbereiche des schmelzflüssigen Metalls (5) des Gießvorrats (4), die sich entlang einem Gießspiegel (14) erstrecken, der durch das

schmelzflüssige Metall des Gießvorrats und die Gießflächen der Walzen (1,2) definiert ist, um entlang dem Gießspiegel (14) eine hochfrequente Relativschwingungsbewegung zwischen dem schmelzflüssigen Metall (5) des Gießvorrats (4) und den Gießflächen der Walzen (1,2) zu induzieren.

2. Verfahren nach Anspruch 1, wobei das Wechselstrommagnetfeld entlang einem Randbereich des Tümpels, der sich entlang einem Gießspiegel (14) erstreckt, der durch das schmelzflüssige Metall (5) des Gießvorrats (4) und die Gießflächen der Walzen (1,2) definiert ist, mit Hilfe eines Paares von Wechselstrom-Elektromagneten (15) angelegt wird, wobei jeder Wechselstrom-Elektromagnet (15) oberhalb des Gießspiegel der entsprechenden Walze (1,2) angeordnet ist und sich im wesentlichen parallel dazu erstreckt, und wobei das Gleichstrommagnetfeld mit Hilfe von Gleichstrom-Elektromagnetelementen angelegt wird, die oberhalb der Wechselstrom-Elektromagneten (15) angeordnet sind.

3. Vorrichtung zum Stranggießen von Metallband, die aufweist: ein Paar parallele Gießwalzen (1,2) mit einem dazwischen ausgebildeten Spalt, eine Metallabgabeeinrichtung (19) zur Abgabe von schmelzflüssigem Metall (5) in den Spalt zwischen den Gießwalzen (1,2), um einen Gießvorrat (4) aus schmelzflüssigem Metall (5) auszubilden, der unmittelbar oberhalb des Spalts auf den Gießwalzenflächen aufliegt, einen Walzenantrieb, um die Gießwalzen in gegenläufiger Richtung anzutreiben und ein erstarrten Metallband (13) zu erzeugen, das aus dem Spalt nach unten ausgetragen wird, und eine Schwingungserzeugungseinrichtung, die so betrieben werden kann, daß sie eine hochfrequente Relativschwingungsbewegung zwischen dem schmelzflüssigen Metall (5) des Gießvorrats (4) und den Gießflächen der Walzen induziert, dadurch gekennzeichnet, daß die Schwingungserzeugungseinrichtung eine Einrichtung (15) zum Erzeugen eines Wechselstrommagnetfelds und eine Einrichtung (16) zum Erzeugen eines Gleichstrommagnetfelds aufweist, wobei die Wechselstrom-Elektromagneteinrichtung (15) im wesentlichen direkt oberhalb eines Randbereichs des schmelzflüssigen Metalls (5) des Gießvorrats (4) und entlang der Länge des Gießspiegels (14) angeordnet ist, der durch das schmelzflüssige Metall des Gießvorrats (4) und die Gießflächen der Walzen so definiert ist, daß Magnetflüsse im wesentlichen senkrecht zur Oberfläche des schmelzflüssigen Metalls verlaufen, und daß die Gleichstrom-Elektromagneteinrichtung (16) so über die Länge der Wechselstrom-Elektromagneteinrichtung (15) angeordnet ist, daß Magnetflüsse im wesentlichen senkrecht zur Oberfläche des schmelzflüssigen Metalls verlaufen.

4. Vorrichtung nach Anspruch 3, wobei die WechselstromElektromagneteinrichtung ein Paar im wesentlichen parallele, beabstandete Wechselstrom-Elektromagneten (15) aufweist, wobei jeder Wechselstrom-Elektromagnet im wesentlichen oberhalb des entsprechenden Gießspiegels (14) angeordnet ist, der durch das schmelzflüssige Metall (5) des Gießvorrats (4) und die Gießfläche jeder Walze (1,2) über die Länge jedes Gießspiegels (14) definiert ist.

5. Vorrichtung nach Anspruch 4, wobei die Gleichstrom-Elektromagneteinrichtung (16) im wesentlichen parallele Gleichstrom-Elektromagnetelemente aufweist, die im wesentlichen oberhalb der entsprechenden Wechselstrom-Elektromagneten (15) angeordnet sind und sich über deren Länge erstrecken.

6. Vorrichtung nach Anspruch 4 oder 5, wobei die Wechselstrom- und Gleichstrom-Elektromagneten (15,16) jeweils in einer wassergekühlten Ummantelung (21,22) untergebracht sind.

7. Vorrichtung nach einem der Ansprüche 4 bis 6, wobei jeder Wechselstrom-Elektromagnet (15) einen langgestreckten kammartigen Kern (36) mit einem langgestreckten plattenartigen Körper und mehreren, gleichmäßig beabstandeten Vorsprüngen, die von einer Längskante des Kerns ausgehen, sowie eine um den äußeren Umfang des Kerns (36) gewickelte Wechselstromspule (27) aufweist.

8. Vorrichtung nach einem der Ansprüche 4 bis 6, wobei jeder Wechselstrom-Elektromagnet (15) mehrere stabartige Kerne (46) aufweist, wobei auf jeden Kern (46) eine Wechselstromspule (37) zylinderförmig aufgewickelt ist.

9. Verfahren zur Schwingungserzeugung in einem schmelzflüssigen Metall in einer Doppelwalzen-Stranggießmaschine, dadurch gekennzeichnet, daß ein Randbereich des schmelzflüssigen Metalls entlang einem Gießspiegel (14), der durch das schmelzflüssige Metall des Gießvorrats definiert ist, durch gleichzeitiges Anlegen eines Gleichstrommagnetfelds und eines Wechselstrommagnetfelds an und entlang dem Gießspiegel (14) in Schwingung versetzt wird, wodurch in dem schmelzflüssigen Metall (5) ein Induktionsstrom erzeugt wird und wegen der Wechselwirkung des Induktionsstroms mit dem Gleichstrommagnetfeld des schmelzflüssigen Metalls durch die Lorentz-Kraft in dem Randbereich eine hochfrequente Schwingung entsteht.

10. Vorrichtung zur Schwingungserzeugung in einem schmelzflüssigen Metall in einer Doppelwalzen-Stranggießmaschine mit mindestens einer Walze (1,2), dadurch gekennzeichnet, daß ein Wechselstrom-Elektromagnet (15) im wesentlichen direkt oberhalb eines Gießspiegels (14) angeordnet ist, der durch das schmelzflüssige Metall (5) in einem Gießvorrat (4) und durch eine Gießfläche der mindestens einen Walze (1,2) über die Länge des Gießspiegels (14) so definiert ist, daß Magnetflüsse im wesentlichen senkrecht zu einer Oberfläche des schmelzflüssigen Metalls (5) verlaufen, und daß ein Gleichstrom-Elektromagnet (16) so über die Länge des WechselstromElektromagneten (15) angeordnet ist, daß Magnetflüsse im wesentlichen senkrecht zur Oberfläche des schmelzflüssigen Metalls verlaufen, um dadurch entlang dem Gießspiegel eine hochfrequente Relativschwingungsbewegung zwischen dem schmelzflüssigen Metall des Gießvorrats und der Gießfläche der mindestens einen Walze zu induzieren.

11. Vorrichtung nach Anspruch 10, wobei die Wechselstrom- und Gleichstrom-Elektromagneten (15,16) jeweils in einer wassergekühlten Ummantelung (21,22) untergebracht sind.

12. Vorrichtung nach Anspruch 14 oder Anspruch 15, wobei der Wechselstrom-Elektromagnet (15) einen langgestreckten kammartigen Kern (36) mit einem langgestreckten plattenartigen Körper und mehreren, gleichmäßig beabstandeten Vorsprüngen, die von einer Längskante des Kerns ausgehen, sowie eine um den äußeren Umfang des Kerns (36) gewickelte Wechselstromspule (27) aufweist.

13. Vorrichtung nach Anspruch 10 oder 11, wobei der Wechselstrom-Elektromagnet (15) mehrere stabartige Kerne (46) aufweist, wobei auf jeden Kern (46) eine Wechselstromspule (37) zylinderförmig aufgewickelt ist.

Revendications

1. Procédé de coulée continue d'une bande de métal, comprenant :

   l'introduction de métal fondu (5) dans un pincement entre deux cylindres de coulée parallèles (1, 2) via des moyens de distribution de métal (19) disposés au-dessus du pincement pour créer une retenue de coulée (4) de métal fondu (5) supportée sur les surfaces de coulée des cylindres (1,2) immédiatement au-dessus du pincement ;
   la mise en rotation en sens inverse des cylindres de coulée (1,2) pour produire une bande de métal solidifié (13) sortant du pincement vers le bas ; et
   l'application d'un mouvement vibratoire de haute fréquence au métal fondu (5) de la retenue de coulée ;
   Caractérisé par l'application simultanée d'un champ magnétique en courant continu et d'un champ magnétique en courant alternatif aux régions de bord du métal fondu (5) de la retenue de coulée (4) s'étendant le long d'un ménisque (14) défini par le métal fondu de la retenue et les surfaces de coulée des cylindres (1,2), afin d'induire un mouvement vibratoire relatif de haute fréquence entre le métal fondu (5) de la retenue de coulée (4) et les surfaces de coulée des cylindres (1,2) le long du ménisque (14).

2. Procédé selon la revendication 1, dans lequel le champ magnétique en courant alternatif est appliqué le long d'une région de bord de la retenue s'étendant le long d'un ménisque (14) défini par le métal fondu (5) de la retenue de coulée (4) et la surface de coulée des cylindres (1,2), au moyen d'une paire d'électroaimants en courant alternatif (15), chaque électro-aimant en courant alternatif (15) étant disposé au-dessus du ménisque de chaque cylindre respectif (1,2) et s'étendant sensiblement parallèlement à celui-ci, et dans lequel le champ magnétique en courant continu est appliqué au moyen d'éléments d'électro-aimant en courant continu disposés au-dessus des électro-aimants en courant alternatif (15).

3. Appareil pour la coulée continue d'une bande de métal, comprenant deux cylindres de coulée parallèles (1,2) définissant un pincement entre eux, des moyens de distribution de métal (19) pour amener du métal fondu (5) dans le pincement entre les cylindres de coulée (1,2) de manière à former une retenue de coulée (4) de métal fondu (5) supportée sur des surfaces des cylindres de coulée immédiatement au-dessus du pincement, des moyens d'entraînement de cylindres pour entraîner les cylindres de coulée en rotation en sens inverse afin de produire une bande de métal solidifié (13) sortant du pincement vers le bas, et des moyens de vibration agissant pour induire un mouvement vibratoire relatif de haute fréquence entre le métal fondu (5) de la retenue de coulée (4) et les surfaces de coulée des cylindres, caractérisé en ce que les moyens de vibration comprennent des moyens (15) de création d'un champ électromagnétique en courant alternatif et des moyens (16) de création d'un champ électromagnétique en courant continu, lesdits moyens électromagnétiques en courant alternatif (15) étant disposés sensiblement directement au-dessus d'une région de bord du métal fondu (5) de la retenue de coulée (4) et s'étendant sur la lon-

gueur d'un ménisque (14) défini par le métal fondu de la retenue de coulée (4) et les surfaces de coulée des cylindres, de sorte que les flux magnétiques s'étendent sensiblement perpendiculairement à la surface du métal fondu, et les dits moyens électromagnétiques en courant continu (16) sont disposés sur la longueur desdits moyens électromagnétiques en courant alternatif (15) de sorte que les flux magnétiques s'étendent sensiblement perpendiculairement à la surface du métal fondu.

4. Appareil selon la revendication 3, dans lequel les moyens électromagnétiques en courant alternatif comprennent deux électro-aimants en courant alternatif (15) sensiblement parallèles et mutuellement espacés, chaque électro-aimant en courant alternatif étant disposé sensiblement au-dessus du ménisque respectif (14) défini par le métal fondu (5) de la retenue de coulée (4) et la surface de coulée de chaque cylindre (1,2) sur la longueur de chaque ménisque (14).

5. Appareil selon la revendication 4, dans lequel les moyens électromagnétiques en Courant continu (16) comprennent des éléments électromagnétiques en courant continu sensiblement parallèles disposés sensiblement au-dessus et s'étendant le long des électro-aimants en courant alternatif respectifs (15).

6. Appareil selon la revendication 4 ou 5, dans lequel les électro-aimants en courant alternatif et en courant continu (15,16) sont tenus par des chemises refroidies à l'eau (21,22); respectivement.

7. Appareil selon une quelconque des revendications 4 à 6, dans lequel chaque électro-aimant en courant alternatif (15) comprend un noyau allongé en forme de peigne (36), comportant un corps allongé en forme de plaque et une pluralité de dents équidistantes s'étendant à partir d'un bord longitudinal du corps, et un enroulement en courant alternatif (27) enroulé autour de la périphérie extérieure du noyau (36).

8. Appareil selon une quelconque des revendications 4 à 6, dans lequel chaque électro-aimant en courant alternatif (15) comprend une pluralité de noyaux en forme de tige (46), chaque noyau (46) ayant un enroulement en courant alternatif (37) enroulé cylindriquement autour de lui.

9. Procédé de communication d'une vibration à un métal fondu dans une machine de coulée continue à cylindres jumelés, caractérisé en ce qu'une vibration est communiquée à une région de bord du métal fondu le long d'un ménisque (14) défini par le métal fondu de la retenue de coulée, par application simultanée d'un champ magnétique en courant continu et d'un champ magnétique en courant alternatif à l'endroit et le long du ménisme (14) afin d'engendrer un courant d'induction dans le métal fondu (5) et de communiquer une vibration de haute fréquence à ladite région de bord du métal fondu par la force de Lorentz due à l'interaction dudit courant d'induction avec ledit champ magnétique en courant continu.

10. Appareil de communication d'une vibration à un métal fondu dans une retenue de coulée d'une machine de coulée continue ayant au moins un cylindre (1,2); caractérisé en ce qu'un électro-aimant en courant alternatif (15) est disposé sensiblement directement audessus d'un ménisque (14) défini par le métal fondu (5) dans une retenue de coulée (4) et une surface de coulée dudit au moins un cylindre (1,2) sur la longueur du ménisque (14) de sorte que les flux magnétiques s'étendent sensiblement perpendiculairement à une surface dudit métal fondu (5), et un électro-aimant en courant continu (16) est disposé sur la longueur dudit électro-aimant en courant alternatif (15) de sorte que les flux magnétiques s'étendent sensiblement perpendiculairement à la surface du métal fondu, afin d'induire un mouvement vibratoire relatif de haute fréquence entre le métal fondu de la retenue de coulée et la surface de coulée dudit au moins un cylindre, le long du ménisque.

11. Appareil selon la revendication 10, dans lequel les électro-aimants en courant alternatif et en courant continu (5,15) sont tenus par des chemises refroidies à l'eau (21,22), respectivement.

12. Appareil selon la revendication 10 ou la revendication 11, dans lequel l'électro-aimant en courant alternatif (15) comprend un noyau allongé en forme de peigne (36), ayant un corps allongé en forme de plaque et une pluralité de dents équidistantes s'étendant à partir du bord longitudinal du corps, et un enroulement en courant alternatif (27) enroulé autour de la périphérie extérieure du noyau (36).

13. Appareil selon la revendication 10 ou 11, dans lequel l'électro-aimant en courant alternatif (15) comprend une pluralité de noyaux en forme de tige (46), chaque noyau (46) ayant un enroulement en courant alternatif (37) enroulé cylindriquement autour de lui.

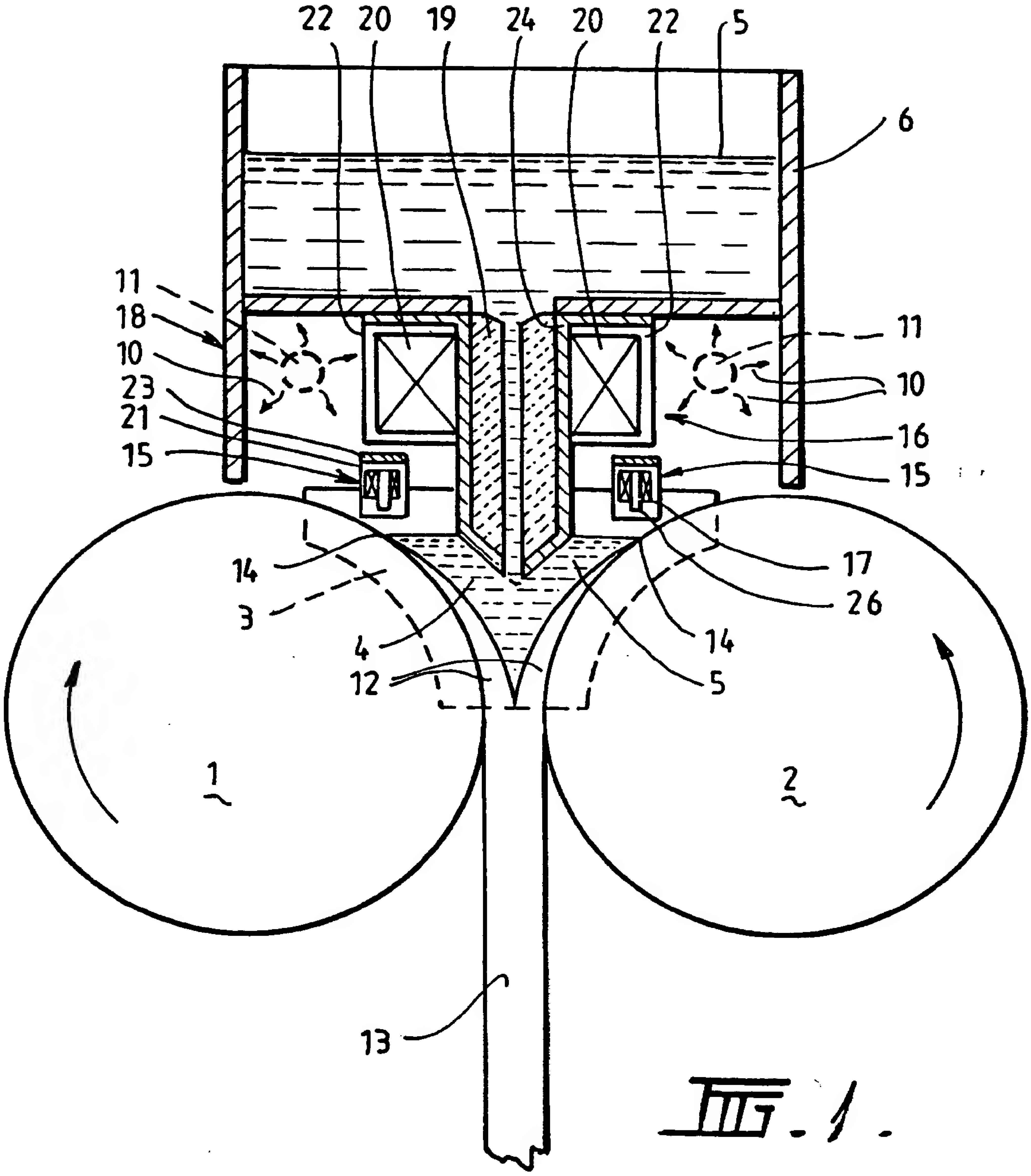
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FIG. 1.

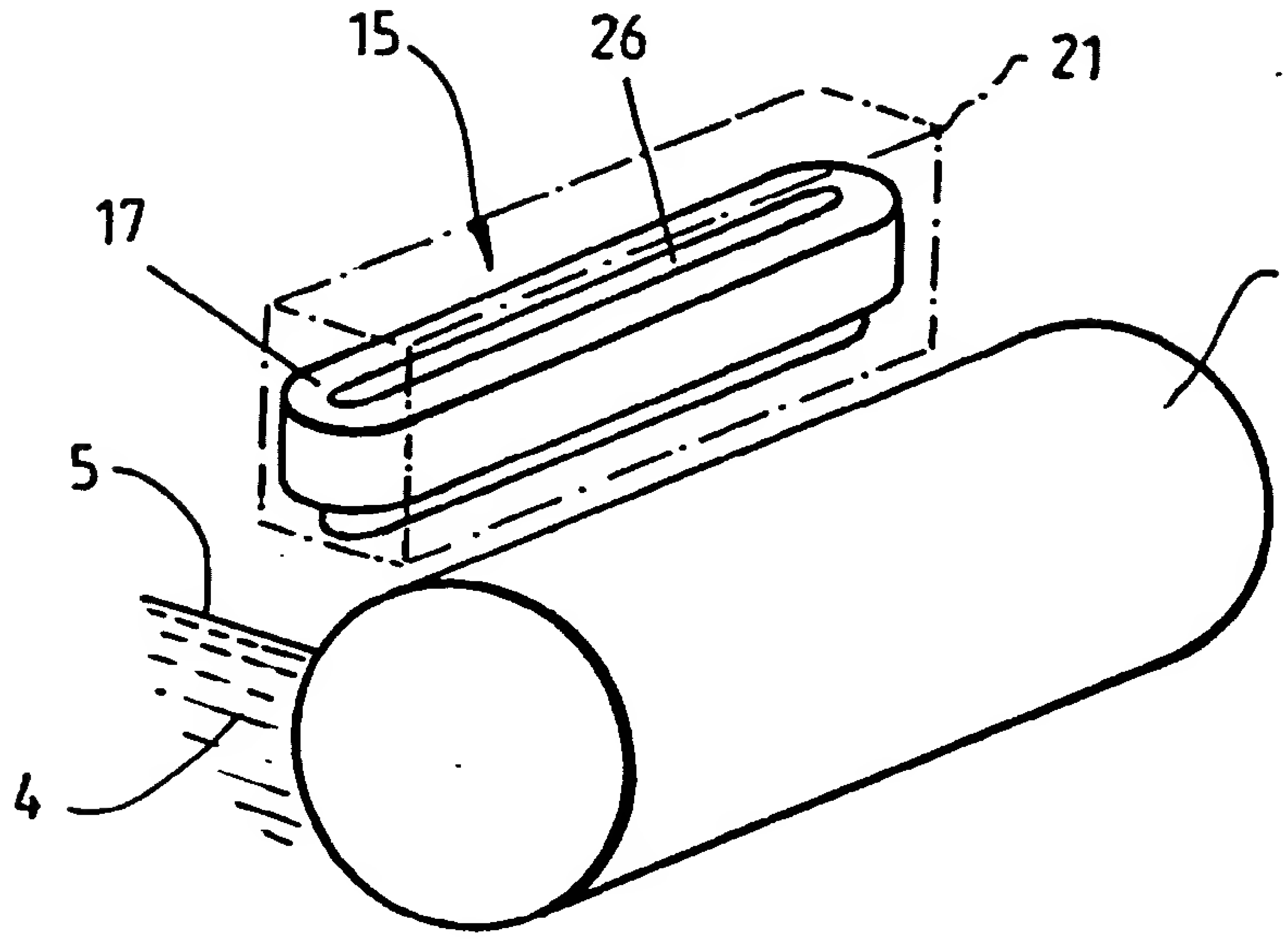
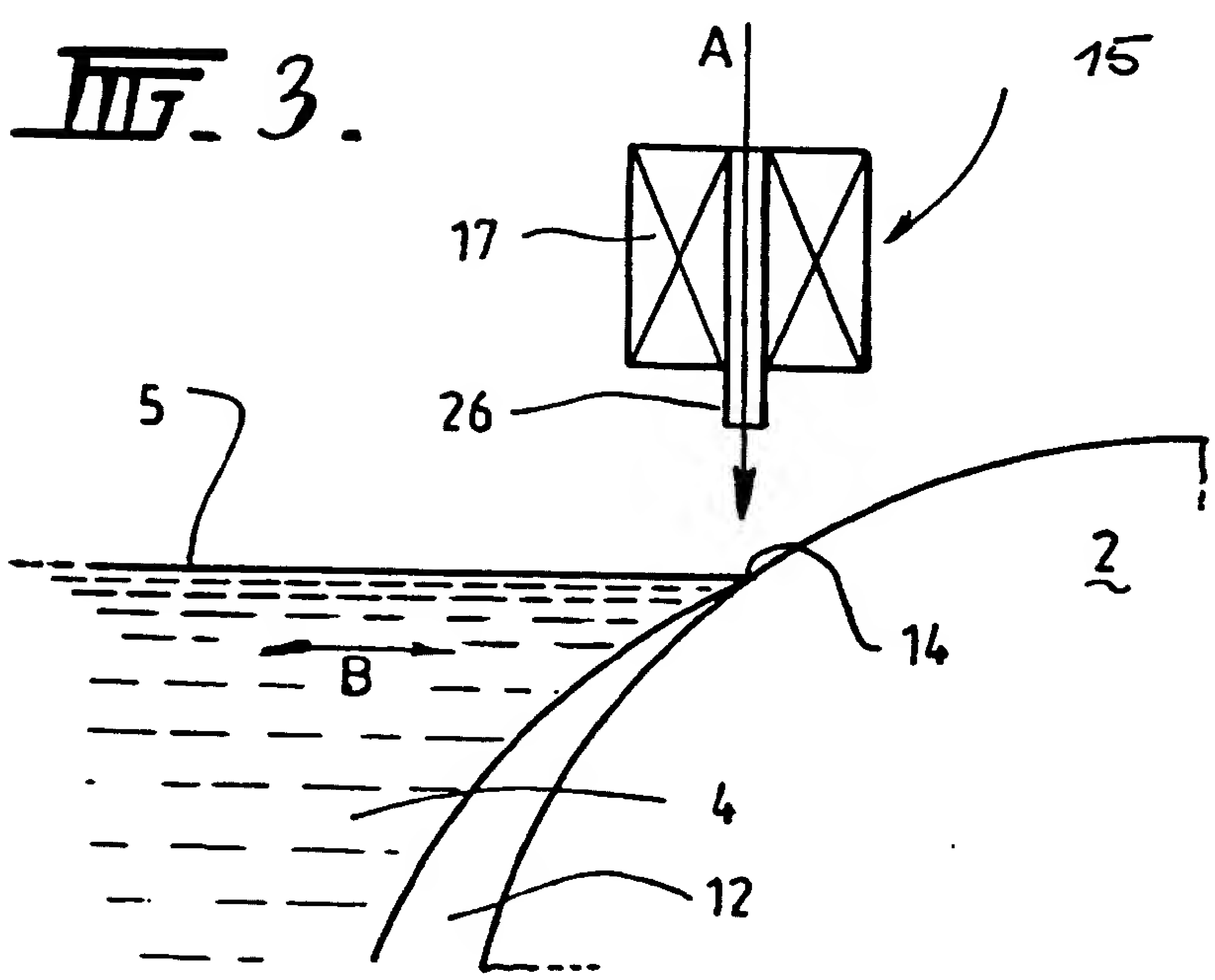


FIG. 2.

FIG. 3.



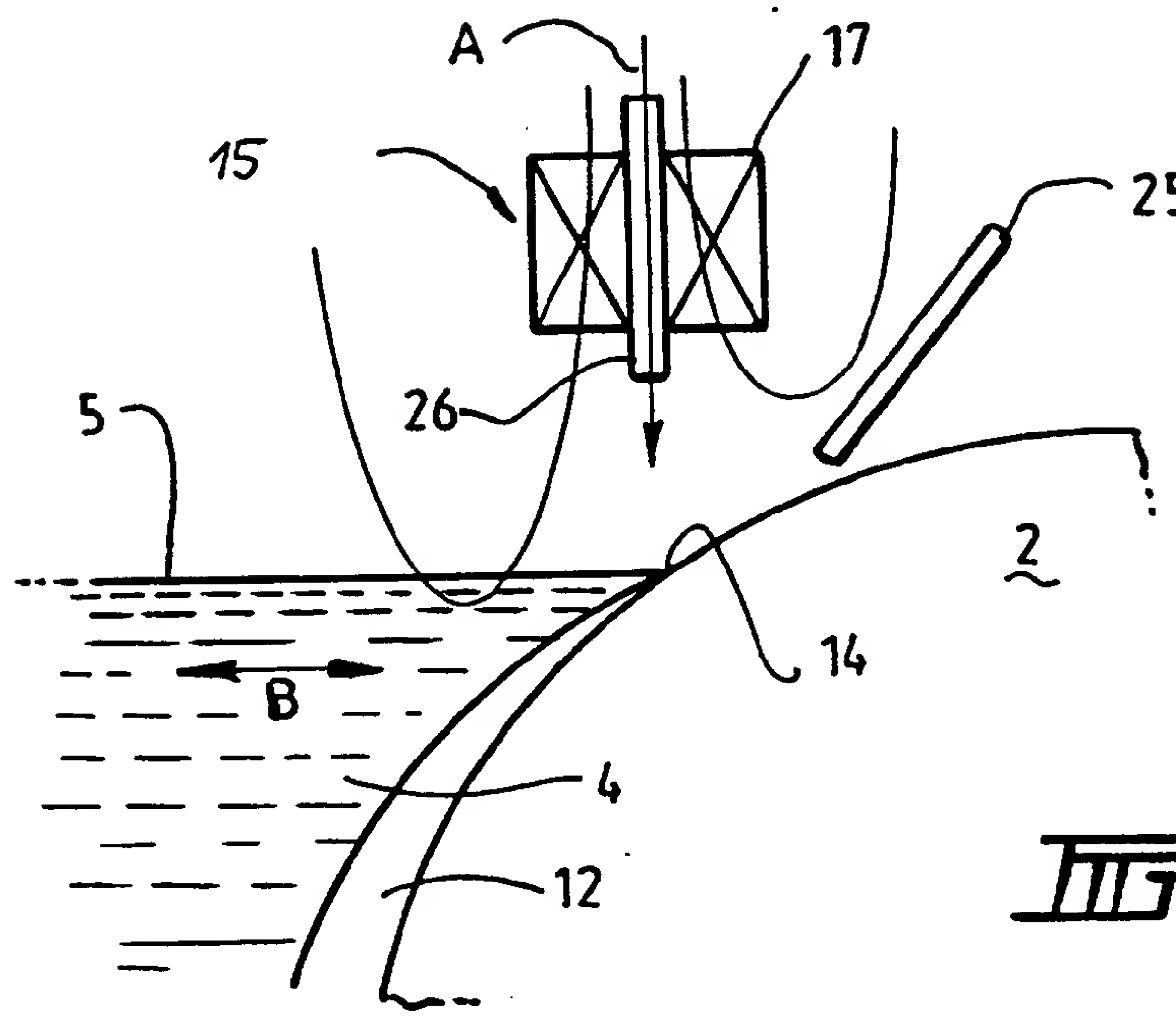


FIG. 4.

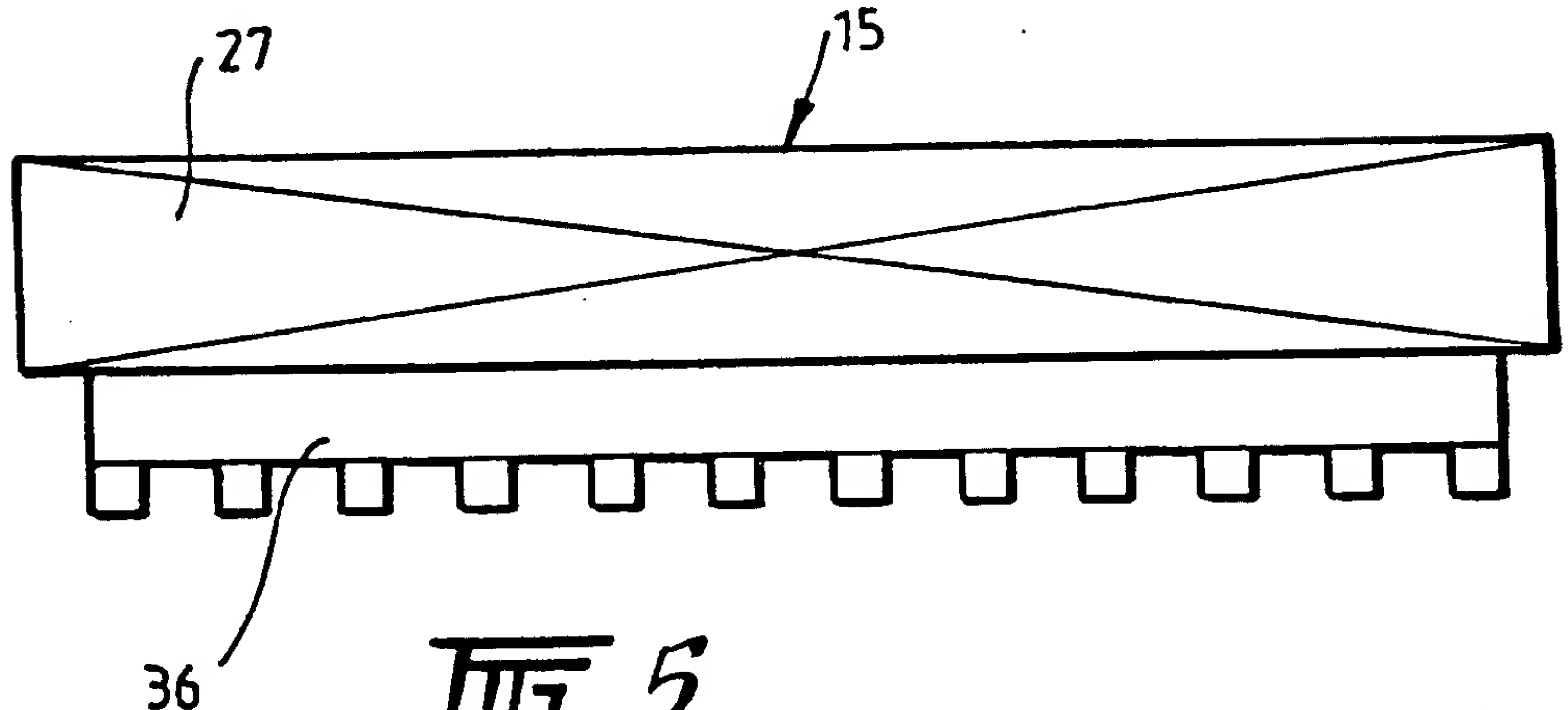


FIG. 5.

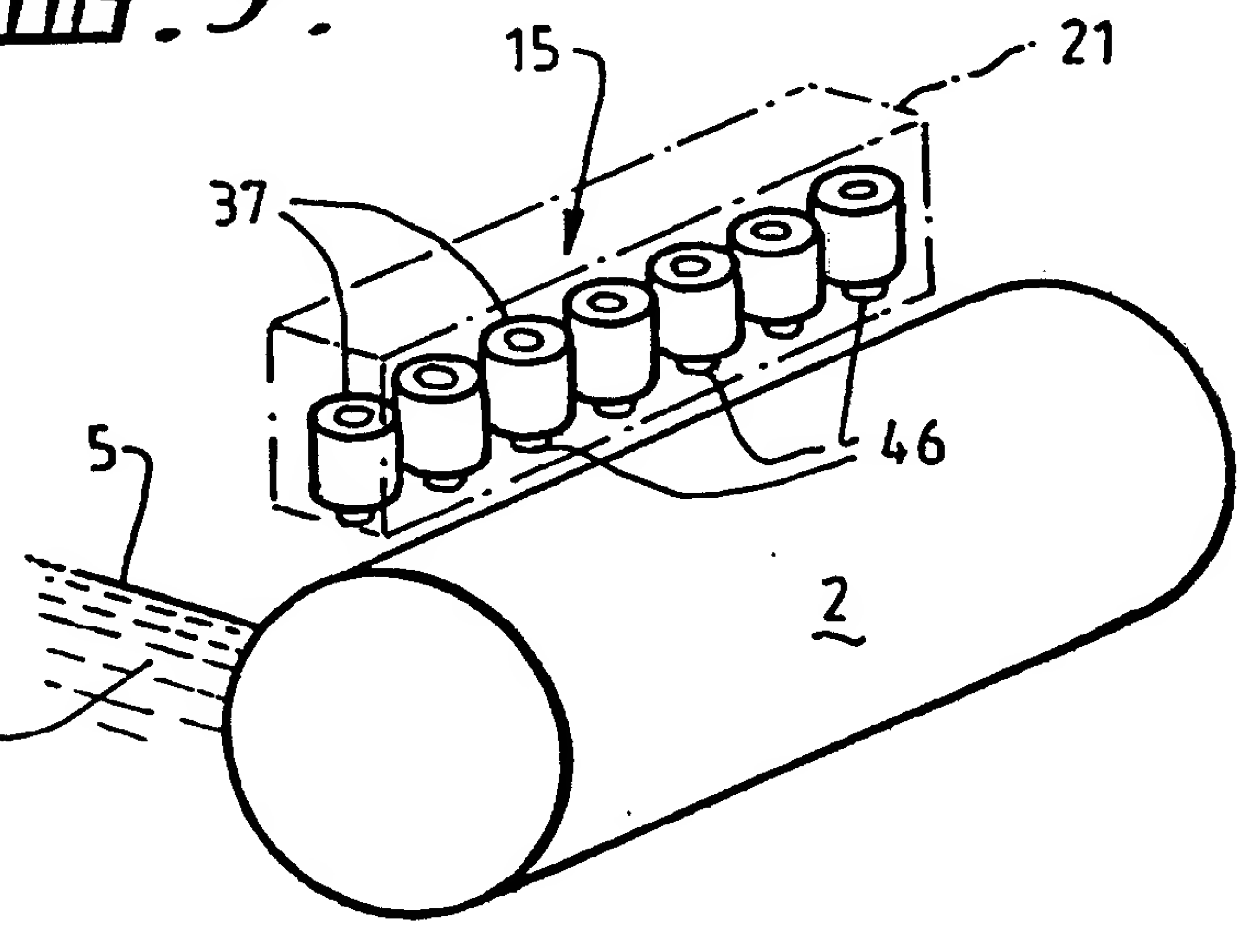


FIG. 6.

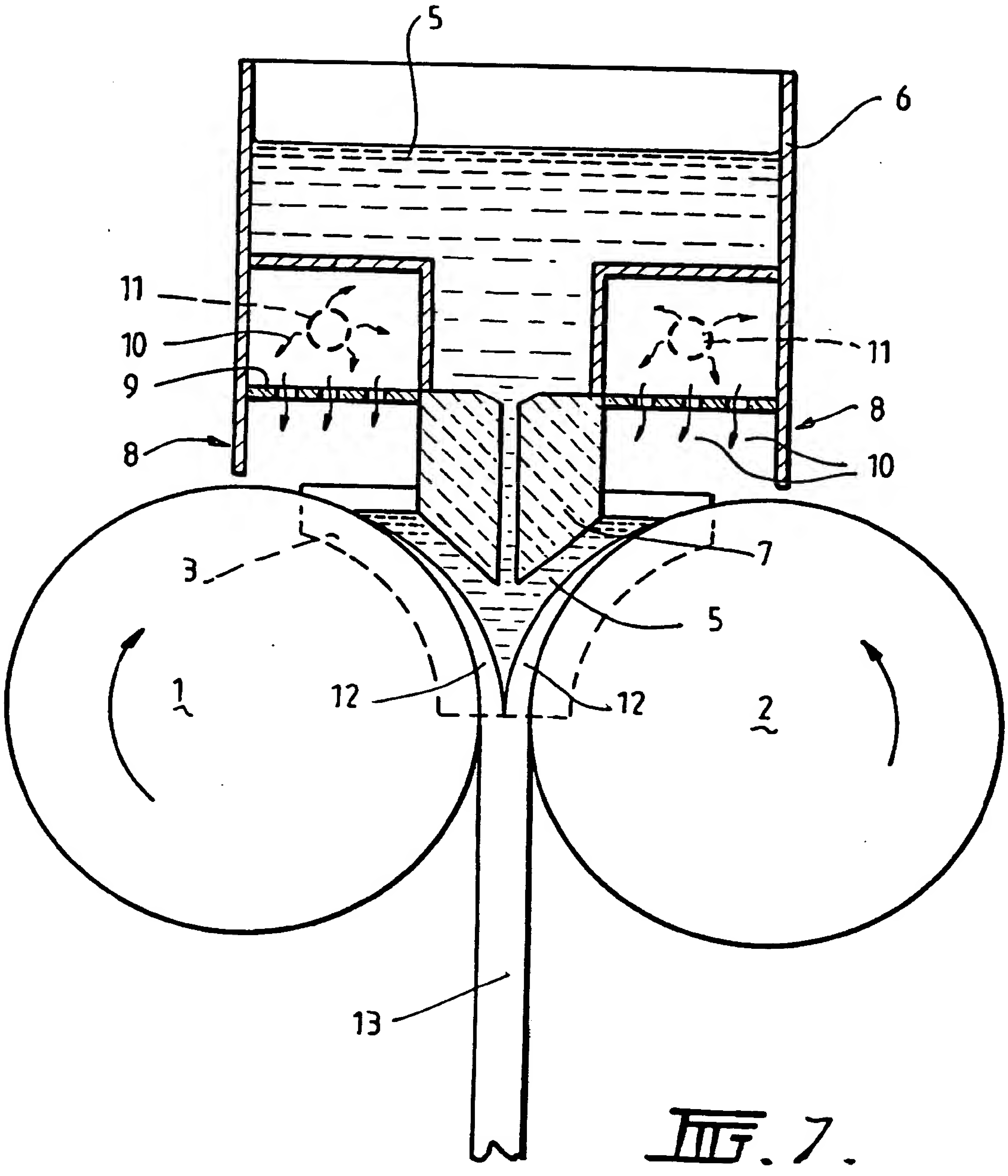


FIG. 7.